MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 2, 2017/2018**

## EEE 7286 – ENERGY MANAGEMENT IN INDUSTRY

05 MARCH 2018
2:00 PM – 5:00 PM
(3 Hours)

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**INSTRUCTIONS TO STUDENTS**

1. This Question paper consists of 7 pages including cover page with 4 Questions only.
2. Answer ALL questions. The distributions of the marks for each question are as stated.
3. Please print all your answers in the Answer Booklet provided.

## Question 1

(a) (i) Describe four different forms of energy.

[8marks]

(ii) Distinguish between renewable energy and non-renewable energy. State two examples of resources for each type of energy.

[8 marks]

(b) A drawing office of 18m x 15m is illuminated with T5 Electronic ballast florescent lamp (datasheet given in Appendix A). The maintenance factor is 0.9 and the coefficient of utilization is 0.6. Calculate

(i) The number of lamp fittings that needs to be installed in order to achieve the average illumination of as recommended in MS1525 (table shown in Appendix B)

[6 marks]

(ii) The total current drawn from the supply of 230 V, 50 Hz.

[3 marks]

## Question 2

Company A decided to perform economic assessment on their electric motors (three phase induction motors). Most of the motors in the company are 15 years old, hence they are below IE1 standard. At the beginning, they selected 5 different motors based on their sizes for the assessment. Details of those motors are given below in Table Q2.

Table Q2

| | kW | Pole | Voltage (V) | Rated Speed (RPM) | Actual Running Speed. (RPM) | Rated Current (A) | Actual Running Amps. (A) | Running Hour per day |
|---|---|---|---|---|---|---|---|---|
| Motor 1 | 11 | 2 | 400 | 2870 | 2860 | 21 | 15.75 | 24 |
| Motor 2 | 7.5 | 2 | 400 | 2870 | 2865 | 15 | 7.5 | 24 |
| Motor 3 | 45 | 2 | 400 | 2983 | 2980 | 87 | 65.25 | 24 |
| Motor 4 | 30 | 2 | 400 | 2983 | 2978 | 58 | 43.5 | 24 |
| Motor 5 | 15 | 2 | 400 | 2950 | 2945 | 30 | 22.5 | 16 |

Given that maximum demand charge is RM 30.8/ kW and tariff rate is RM 0.25/kWhr. The company operates 25 days in a month.

a) Calculate the total losses in kWhr per month based on details given in Table Q2. Given approximate power factor values for the motors are 0.9 at full load, 0.86 at ¾ load and 0.8 at half load.

[9 marks]

**Continued...**

b) Calculate again the total losses in kWhr per month if all the motors are IE2 motors. (Efficiency for IE2 motors are given in Appendix C)

[6 marks]

c) Motor 3 is used to drive a fan. The average flow rate for the fan is 50% and currently the flow rate is controlled using a damper. Explain how variable speed drives can improve the efficiency of the fan. Calculate the payback period for the cost involved for the improvement. Given that the cost of variable speed drives and installation is RM60,000, and electricity tariff is RM0.40/unit)

[10 marks]

**Question 3**

(a) The capital cost of a power generating equipment in a power plant is RM 200 million. The useful life of the equipment is 25 years and its salvage value is 7.0% of its total cost. Determine the amount of money to be deposited annually for replacement by sinking-fund method. Assume that the annual compound interest is 5.0%.

[5 marks]

(b) State and explain any five tariff structures used by the utilities.

[10 marks]

(c) An industry consumes 3 million unit energy per annum with a maximum demand of 2000 kW at 0.85 pf lagging. They use Tariff E1 (Malaysian Utility Tariff) for medium voltage industry.

(i) Calculate the annual bill if the tariff rate is as follows:
Maximum demand charge = RM29.60/kW
Energy charge = RM0.3370/kWhr

[4 marks]

(ii) Explain three solutions to reduce maximum demand of the industry.

[6 marks]

**Continued...**

## Question 4

(a) Define building envelope and state two solutions to increase the thermal energy efficiency of a building.

[4 marks]

(b) Define indoor air quality for a building. Explain three control strategies for the indoor air quality.

[5 marks]

(c) What is a captive power plant? Discuss the need for a captive power plant in an industry.

[7 marks]

(d) A captive power plant (CPP) located in an industry is operating in parallel with the grid. The total power requirement of the industry is 50 MW at 0.85 power factor lagging. Total real and reactive power losses in the distribution system of the industry are 2 MW and 1.5 MVAR, respectively. The real and reactive powers generated by the captive generator are 30 MW and 20 MVAR, respectively. It is desirable to import power from the grid at unity power factor. A capacitor bank is connected at the 11 kV of the CPP bus to adjust the power factor. Calculate the real and reactive powers to be imported from the grid and the value of capacitor connected at the 11 kV bus.

[9 marks]

**Continued...**

## Appendix A

Product datasheet

OSRAM

HE 14 W/827

LUMILUX T5 HE | Tubular fluorescent lamps 16 mm, high efficiency, with G5 base

Product datasheet

Technical data

### Electrical data

| | |
|---|---|
| Nominal voltage | 220 V |
| Nominal wattage | 14.0 W |
| Rated lamp efficacy (HF data 25 °C) | 86 lm/W |
| Rated wattage | 14.00 W |

### Photometrical data

| | |
|---|---|
| Color rendering index Ra | ≥80 |
| Rated luminous flux | 1200 lm |
| Luminous flux at 25 °C | 1200 lm |
| Luminous flux at 35 °C | 1350 lm |
| Light color | 827 |
| Color temperature | 2700 K |
| Nominal luminous flux | 1200 lm |
| Light color (designation) | LUMILUX INTERNA |
| Rated LLMF at 2,000 h | 0.95 |
| Rated LLMF at 4,000 h | 0.92 |
| Rated LLMF at 6,000 h | 0.91 |
| Rated LLMF at 8,000 h | 0.90 |
| Rated LLMF at 12,000 h | 0.90 |
| Rated LLMF at 16,000 h | 0.90 |
| Rated LLMF at 20,000 h | 0.89 |

**Continued...**

## Appendix B

**Table 10. Recommended average illuminance levels**

| Task and Applications | Illuminance (Lux) | Minimum CRI |
|---|---|---|
| a) Lighting for infrequently used area: | | |
| - Minimum service illuminance | 20 | 30 |
| - Interior walkway and car-park | 100 | 40 |
| - Hotel bedroom | 100 | 60 |
| - Lift interior | 100 | 40 |
| - Corridor, passageways, stairs | 100 | 40 |
| - Escalator, travellator | 150 | 40 |
| - Entrance and exit | 100 | 60 |
| - Staff changing room, locker and cleaner room, cloak room, lavatories, stores. | 100 | 60 |
| - Entrance hall, lobbies, waiting room | 100 | 60 |
| - Inquiry desk | 300 | 80 |
| - Gate house | 200 | 80 |
| b) Lighting for working interiors | | |
| - Infrequent reading and writing | 200 | 80 |
| - General offices, shops and stores, reading and writing | 300 - 400 | 80 |
| - Drawing office | 300 - 400 | 85 |
| - Restroom | 150 | 80 |
| - Restaurant, canteen, cafeteria | 200 | 80 |
| - Kitchen | 150 - 300 | 80 |
| - Lounge | 150 | 60 |
| - Bathroom | 150 | 80 |
| - Toilet | 100 | 60 |
| - Bedroom | 100 | 80 |
| - Class room, library | 300 - 500 | 80 |
| - Shop/supermarket/department store | 200 - 750 | 80 |
| - Museum and gallery | 300 | 80 |
| c) Localised lighting for exacting task | | |
| - Proof reading | 500 | 80 |
| - Exacting drawing | 1000 | 80 |
| - Detailed and precise work | 2000 | 80 |

**Continued...**

# Appendix C : IE2 Motors

**TEFC, Class F, 40°C Ambient Temperature, IEC; Design N Continuous Duty, S. F. 1.0** 380V/50Hz

| OUTPUT | | | | EFFICIENCY | | | POWER FACTOR | | | CURRENT | | TORQUE | | | | ROTOR GD$^2$ | NOISE SOUND POWER NO-LOAD | APP. WEIGHT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KW | hp | FULL LOAD rpm | FRAME NO. | FULL LOAD % | 3/4 LOAD % | 1/2 LOAD % | FULL LOAD PF | 3/4 LOAD PF | 1/2 LOAD PF | FULL LOAD A | LOCKED ROTOR %FLT | FULL LOAD Nm | LOCKED ROTOR %FLT | PULL UP %FLT | BREAK DOWN %FLT | | | |
| | | | | | | | | | | | | | | | | kgm$^2$ | dB(A) | kg |
| 7.5 | 10 | 2905 | 132S | 88.1 | 88.6 | 87.6 | 84.5 | 80.5 | 71.5 | 15.3 | 660 | 2.499 | 190 | 165 | 250 | 0.068 | 97 | 67 |
| | | 1465 | 132M | 88.7 | 89.0 | 88.8 | 85.5 | 80.5 | 70.0 | 15.0 | 760 | 4.955 | 230 | 165 | 280 | 0.133 | 90 | 78 |
| | | 960 | 160M | 87.2 | 88.0 | 87.0 | 81.5 | 76.5 | 66.0 | 16.0 | 600 | 7.561 | 210 | 185 | 225 | 0.363 | 82 | 110 |
| 11 | 15 | 2940 | 160M | 89.4 | 89.4 | 88.6 | 91.5 | 89.0 | 83.0 | 20.4 | 830 | 3.703 | 220 | 155 | 270 | 0.154 | 97 | 105 |
| | | 1465 | 160M | 89.8 | 90.1 | 89.5 | 88.5 | 85.0 | 77.5 | 21.0 | 730 | 7.432 | 205 | 155 | 255 | 0.297 | 90 | 110 |
| | | 965 | 160L | 88.7 | 89.2 | 88.6 | 81.5 | 76.0 | 65.0 | 23.1 | 665 | 11.280 | 245 | 230 | 270 | 0.558 | 85 | 140 |
| 15 | 20 | 2925 | 160M | 90.3 | 90.3 | 90.2 | 93.0 | 91.5 | 88.0 | 27.1 | 765 | 4.963 | 230 | 155 | 240 | 0.192 | 100 | 120 |
| | | 1470 | 160L | 90.6 | 91.3 | 90.5 | 86.5 | 82.5 | 73.5 | 29.1 | 785 | 9.876 | 235 | 185 | 280 | 0.396 | 94 | 130 |
| | | 975 | 180L | 89.7 | 89.7 | 88.4 | 80.0 | 74.0 | 62.5 | 31.8 | 760 | 14.890 | 265 | 185 | 315 | 1.342 | 88 | 200 |
| 18.5 | 25 | 2945 | 160L | 90.9 | 91.7 | 90.5 | 92.5 | 90.5 | 86.0 | 33.4 | 880 | 6.162 | 265 | 175 | 280 | 0.237 | 100 | 135 |
| | | 1470 | 180M | 91.2 | 92.0 | 91.0 | 85.0 | 82.5 | 75.5 | 36.3 | 630 | 12.340 | 160 | 175 | 275 | 0.654 | 94 | 180 |
| | | 975 | 200L | 90.4 | 91.1 | 90.2 | 82.5 | 79.0 | 70.5 | 37.7 | 610 | 18.610 | 200 | 185 | 220 | 1.604 | 88 | 250 |
| 22 | 30 | 2945 | 180M | 91.3 | 91.5 | 91.0 | 90.0 | 88.0 | 82.5 | 40.7 | 800 | 7.394 | 220 | 175 | 280 | 0.283 | 100 | 175 |
| | | 1475 | 180L | 91.6 | 91.8 | 91.5 | 84.0 | 80.5 | 72.5 | 43.4 | 710 | 14.760 | 195 | 150 | 230 | 0.712 | 94 | 190 |
| | | 975 | 200L | 90.9 | 91.1 | 90.9 | 82.0 | 78.5 | 69.5 | 44.8 | 680 | 22.330 | 225 | 180 | 220 | 1.912 | 88 | 270 |
| 30 | 40 | 2955 | 200L | 92.0 | 92.0 | 90.8 | 90.0 | 89.0 | 85.0 | 55.0 | 775 | 9.825 | 185 | 140 | 275 | 0.521 | 102 | 240 |
| | | 1475 | 200L | 92.3 | 92.3 | 91.7 | 87.5 | 84.5 | 77.5 | 56.4 | 790 | 19.680 | 205 | 185 | 245 | 1.220 | 98 | 255 |
| | | 975 | 225M | 91.7 | 92.0 | 91.5 | 86.0 | 83.5 | 76.0 | 57.8 | 615 | 29.780 | 175 | 155 | 210 | 2.442 | 91 | 325 |
| 37 | 50 | 2950 | 200L | 92.5 | 92.0 | 91.3 | 90.5 | 89.5 | 85.5 | 67.2 | 845 | 12.30 | 205 | 140 | 240 | 0.663 | 102 | 270 |
| | | 1480 | 225S | 92.7 | 92.8 | 92.1 | 87.0 | 84.0 | 77.0 | 69.7 | 710 | 24.52 | 190 | 160 | 245 | 1.649 | 98 | 320 |
| | | 980 | 250M | 92.2 | 92.4 | 91.9 | 85.0 | 81.0 | 72.5 | 71.7 | 640 | 37.03 | 180 | 180 | 220 | 3.373 | 91 | 410 |
| 45 | 60 | 2965 | 225M | 92.9 | 92.3 | 90.9 | 90.5 | 87.5 | 81.0 | 81.3 | 875 | 14.89 | 180 | 155 | 320 | 1.074 | 104 | 320 |
| | | 1475 | 225M | 93.1 | 93.3 | 92.9 | 86.5 | 83.5 | 76.5 | 84.9 | 690 | 29.53 | 190 | 160 | 270 | 1.731 | 100 | 330 |
| | | 985 | 280S | 92.7 | 92.6 | 92.0 | 84.0 | 81.0 | 73.5 | 87.8 | 650 | 44.52 | 140 | 115 | 230 | 6.400 | 94 | 580 |

**End of Paper**